INFLUENCE OF POLAR-CAP ALBEDO ON PAST AND CURRENT MARTIAN
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The bolometric reflectance of the Martian polar caps is a significant
term in the annual heat budget of the caps and, in turn, in the current
seasonal climate. The albedos of the polar caps were observed by the
Viking Orbiters to vary significantly with time and location (1,2):
albedos of the two caps differ, but generally increase with insolation
intensity. Possible contributing "micromechanisms" include grain growth
through metamorphism, floating away or sinking of included dust grains,
subsurface sublimation and surface recondensation of CO_2, and surface
concentration of frozen H_2O. Although the importance of each of these
mechanisms is still uncertain, seasonal-cap models that incorporate the
observed albedo variation and the hemispheric difference in polar
topography correspond better than other models to the observed annual
surface-pressure cycle. Observations by the Mars Observer could
distinguish among many of these micromechanisms.

Frost metamorphism is expected to result in grain growth on the order
of $100 \mu m$ diameter in half a Martian year and would yield a decrease in
albedo through the spring and summer. Stokes "floating" is predicted for
dust grains of diameters less than $10 \mu m$ that reach the cap surface under
typical polar summer conditions; this process would yield a constant albedo
for dust that initially was uniformly mixed. Radiative transfer in dusty
CO_2, which includes sinking motion of individual grains relative to the
subliming surface (due to their greater absorption of insolation), has been
modeled and does demonstrate the observed brightening. This model also
predicts subsurface sublimation and surface frost growth due to the smaller
extinction coefficient for thermal versus solar wavelengths. The
concentration effect of H_2O frost grains depends upon relative grain size,
but it is unlikely to be significant because of the similarity between CO_2
and H_2O single-scattering albedos. The magnitudes of these micromechanisms
will vary in different ways with the astronomical variation of insolation.

The variability of CO_2 frost albedo will be important for long-term
climate models; the frost albedo will depend upon the dustiness of the
atmosphere, and hence upon the atmospheric surface pressure and dynamics.
In models that include both the polar caps and the regolith as volatile
reservoirs, the free (atmosphere + cap) volatile inventory depends largely
on the soil albedo and the obliquity; however, the surface atmospheric
pressure is still controlled by the vapor pressure of a perennial polar cap
(3). This mutual dependence of surface pressure, amount of atmospheric
dust, frost albedo, and stability of the polar caps make predictions at
different obliquities quite uncertain. The variation of obliquity is the
dominant term in the astronomical control of Martian climate (4,5); yet,
the total range of obliquity is equivalent to an albedo range of 0.65 to
0.88, a range readily accomplished by dusty and clean CO_2 frosts. In
Martian climate models, polar-frost albedo has commonly been assumed to be
constant; this simplifying assumption about a major parameter in the annual
volatile cycle brings into question at least the quantitative aspects of
such models. An understanding of the processes governing current Martian

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climate is required before reliable extrapolations can be made to other conditions.

Another challenge for climate models is to distinguish between the effects of the precessional hemispheric asymmetry, which probably controls the season of the dust storms and has a cycle of 50,000 years, and the topographic hemispheric asymmetry, which may influence the global circulation patterns and which perseveres over the astronomical insolation cycles.

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